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Various regimes of instability and formation of coastal eddies along the shelf bathymetry

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The impact of shelf slope on the stability of coastal currents and the nonlinear formation of coastal meanders and eddies are investigated by linear analysis and numerical simulations using an idealized channel configuration of the ROMS model. The impact of the shelf bathymetry leads to different regimes of instability of coastal currents that can both enhance or prevent the cross-shore transport. While keeping unchanged a coastal jet, we tested its unstable evolution for various depth and topographic slopes. Unlike standard linear stability analysis devoted to the very first stage of instability we focus on the non-linear end state, i.e. the formation of coastal eddies or meanders, to classify the various dynamical regimes. Two dimensionless numbers are used to quantify the parameter space of theses various regimes: the vertical aspect ratio gamma and the topographic parameter Tp, which is defined as the ratio of the topographic Rossby waves speed over the jet speed and is proportional to the shelf slope. We found four distinct regimes of instability, namely: standard baroclinic instability, horizontal shear instability, trapped coastal instability and quasi-stable jet. Our results show that Tp is the key parameter that controls the non-linear saturation of the coastal current, while gamma controls the transition from the standard baroclinic instability to the horizontal shear instability. Moreover, our analysis exhibit a new regime of formation of submeso-scale eddies. Contrary to the standard baroclinic instability regime, these eddies are trapped over the slope and never escape off-shore.